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RESEARCH ARTICLE

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Adverse childhood experiences and their relationship to complex health profiles among child welfare–involved children: A classification and regression tree analysis

Samantha M. Brown PhD[1] | Kimberly Bender PhD[2] | Rebecca Orsi PhD[3] | Julie S. McCrae PhD[4] | Jon D. Phillips PhD[2] | Shauna Rienks PhD[5]

[1]School of Social Work, Colorado State University, Fort Collins, Colorado

[2]Graduate School of Social Work, University of Denver, Denver, Colorado

[3]Social Work Research Center, Colorado State University, Fort Collins, Colorado

[4]Chapin Hall Center for Children at the University of Chicago, Chicago, Illinois

[5]Graduate School of Social Work, University of Denver, Butler Institute for Families, Denver, Colorado

Correspondence
Samantha M. Brown, PhD, School of Social Work, Colorado State University, 1586 Campus Delivery, Fort Collins, CO, 80523-1586.
Email: Samantha.Brown@colostate.edu

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Abstract

Objective: To identify the clustering of adverse childhood experiences (ACEs) that best characterize child welfare–involved children with known complex health concerns.

Data Source: Multi-informant data were obtained from Wave I of the National Survey of Child and Adolescent Well-Being (NSCAW II).

Study Design: This study used a cross-sectional design and classification and regression tree (CART) analyses.

Data Collection: Data were collected from families with children, aged birth to 17, investigated for child maltreatment and their child protective services caseworkers, including demographic characteristics of the children, their histories of adversity, and a wide range of health concerns.

Principal Findings: Results indicate that for children between the ages of six and 17, experiences of physical abuse alone, as well as experiences of physical abuse combined with having a caregiver with mental illness, are most strongly associated with complex health concerns. For children aged 2-5 years, results suggest that caregiver mental illness is a key adverse experience associated with complex health concerns.

Conclusions: Identifying specific combinations of ACEs may be a critical next step for child- and youth-serving agencies to allow providers to better calculate risk of health problems among children exposed to adversity.

KEYWORDS
adverse childhood experiences, child welfare, classification and regression tree, health concerns

1 | INTRODUCTION

Exposure to childhood maltreatment and other adverse childhood experiences (ACEs) place children at increased risk for negative physical, developmental, and mental health outcomes. Children involved in the child welfare system are particularly vulnerable to adversity, with more than half of these children experiencing four or more ACEs.[1] According to the seminal ACE study conducted by Felitti and colleagues,[2] ACEs comprise several family-based experiences that occur before age 18, including exposures to abuse, neglect, caregiver incarceration, and household substance use, mental illness, or domestic violence. Additional researchers have further conceptualized ACEs to include other experiences such as caregiver separation and divorce.[1]

In addition to elevated exposure to early adversity, children involved with child welfare are also more likely to experience complex health challenges, including higher-than-average rates of physical, developmental, and mental health problems, often in combination.[3-5] Specifically, child welfare–involved children evidence high scores in internalizing and externalizing problem behaviors,[6] cognitive and social impairments,[7] and chronic health conditions such as asthma and diabetes that would indicate service need.[5] Since the influential ACE study,[2] researchers have made great advancements in understanding the relationship between ACEs and health outcomes in adults.[8-10] More recent research has begun exploring how *current* experiences of ACEs relate to *current* health challenges among children and youth.[11-14] However, less is known about which ACEs are most salient in their association with health outcomes in young, vulnerable populations. Such information may be helpful for designing service approaches in health care and child welfare that aim to mitigate emerging health concerns.

Extant research on ACEs predominantly links cumulative childhood adversities with development of poor health outcomes in both adults and children. Notably, ACEs and health problems relate in a dose-response manner such that, with each additional ACE, the odds of negative health concerns increase. Retrospective studies examining the long-term impact of ACEs have demonstrated that, compared to adults with no early adversity, those with four or more ACEs were 4-12 times more likely to have health risks including drug and alcohol abuse, depression, and suicidal ideation.[2] Similar results are found in studies of children. For example, children experiencing more than one ACE were more than twice as likely to have dental caries,[12] 38 percent more likely to exhibit poor emotional well-being,[11] and 21 percent more likely to have a chronic medical condition.[13] Furthermore, in our own research with children investigated for maltreatment, we found that for each additional ACE, children and youth were 29-44 percent more likely to have complex health concerns, depending on the developmental stage of the child.[14]

Although robust evidence exists that examines cumulative ACEs and the risk of poor health outcomes, less research has focused on patterns or clustering of specific ACEs that may lead to such risk. One study used factor analysis to investigate how ACEs group together to form constructs of early adversity among children and adolescents.[15] Results indicated that certain ACEs are more interrelated than others, with ACEs grouping together according to abuse, household dysfunction, and mixed adversity.[15] In addition, Lanier and colleagues[16] used latent class analysis to examine classes of ACEs in relation to child health outcomes. A subgroup of children that were exposed to poverty and caregiver mental illness were more likely to have special health care needs than were children classified into other subgroups.[16] To our knowledge, however, few studies have used analytic strategies that explore the clustering of ACEs and how they interact to identify children and youth with low- and high-risk health concerns.

One analytic strategy that can determine whether individual ACEs or a particular combination of ACEs is more related to child health outcomes is classification and regression tree (CART) analysis. CART analysis uses a decision tree methodology to determine which variables cluster together to characterize individuals according to a particular outcome. Thus, CART analysis can be a useful method for assessing the clustering of multiple ACEs that most accurately relate to being in a group that has complex health concerns or being in a group that has lower health concerns. CART analysis has been widely used in the fields of public health and medicine as a diagnostic of poor health outcomes. For example, to combat the obesity epidemic, a combination of variables (ie, high early weight gain and obese parents) have been shown to identify children at risk of becoming overweight.[17]

Knowledge gained from CART analysis may better assist professionals in differentiating adversity-exposed children most at risk for poor health, thereby increasing the opportunity to intervene early to improve children's short- and long-term health outcomes. However, current research suggests that few health professionals inquire about adversity experienced in childhood in order to make accurate projections of children's health trajectories;[18] and professionals in other child- and family-serving disciplines that do screen for adversity in childhood are often unable to link children to effective interventions.[19] For example, in a sample of pediatricians with frequent contact with young children, only 4 percent asked about, or screened for, ACEs; and almost no pediatric professionals reported using formal tools to screen for early adversity in families,[18] complicating the ability to address social determinants of health. In fact, fewer than 11 percent of pediatricians in the sample reported familiarity with the ACE study conducted by Felitti and colleagues.[2] Failing to ask about early adversities may be a missed opportunity to assist families in accessing services, as many children with high ACE scores or child welfare involvement are less likely to participate in early intervention programs[20] and have unmet health needs.[21] Findings from classification tree models may help health care providers and other child- and family-serving providers, such as child welfare staff, understand the long-term benefits to inquiring about adversity in childhood due to its association with children's health risk.

Research that considers the importance of specific ACEs and their combinations in relation to children's negative health outcomes is largely absent from the literature. Therefore, the purpose of this study was to identify the clustering of ACEs that best characterize child welfare–involved children with known complex health concerns (having multiple needs across developmental, physical, and mental health). This information may be useful to provide a deeper understanding of these relationships and allow professionals to better calculate risk of health problems in order to refer children for further assessment and services.

2 | METHOD

2.1 | Sample design and procedures

This study used data collected from Wave I of the National Survey of Child and Adolescent Well-Being (NSCAW II) and includes a national

sample of 5873 children, aged birth to 17, whose families were investigated for child protective services. Data were obtained through reports from caregivers, children (age 11 and up), and child protective services caseworkers. The sample design involved a two-stage stratified cluster sample of children with primary sampling units (PSU) that consisted of child protective services representing different geographic regions in the United States (for more information on sampling, see NSCAW II documentation[22]).

2.2 | Study sample

In a previous study, we conducted latent class analysis (LCA) for children in each of four developmental stages (infancy, preschool-age, school-age, and adolescence) to identify groups of children who were similar to each other based on their physical, behavioral, and developmental health conditions.[4] For each developmental stage, a two-class model had the best fit, revealing a complex health concerns group in which children evidenced multiple clinical-level health conditions, and a lower health concerns group in which children evidenced fewer clinical-level health conditions at the time of child welfare investigation. When summed across developmental stages, the number of children in the "complex health concerns" class was 1234, while the number of children in the class with fewer concerns was 4636. As a result of the high imbalance in these class distributions, the present study sample included all children with complex health concerns and randomly selected subsamples of the lower health concerns group to create an analytic sample balanced across complex and lower health concerns. To facilitate robust CART analysis, we created three different subsamples of 1238 children with lower health concerns, which contain essentially equal numbers of children with both types of health profiles (N = 2472 for each analysis). Each subsample of children with lower health concerns was stratified by age group and ethnicity to ensure that the characteristics of the subsamples were similar to the characteristics of the entire group of children in the NSCAW who have lower health concerns.

2.3 | Measures

2.3.1 | Dependent variable

The dichotomous health concerns outcome variable resulted from latent class analysis (LCA) conducted in a previous study that identified children as having complex health concerns or lower health concerns.[4] Eleven health indicators (gleaned primarily from standardized measures) were used to establish the extent to which children demonstrated concerning symptoms or behaviors in each of the following domains: physical health, which was composed of reports of general (eg, under/overweight, hearing, eyesight), acute (eg, serious injury or accident), or chronic health conditions (eg, allergy, asthma, headaches); developmental health (speech/language and/or social-emotional, cognitive, and neurodevelopmental); and behavioral health (temperament or internalizing, externalizing, and trauma symptoms). Not all indicators were available for all children as administration of particular tools was based on their age appropriateness (eg, the trauma symptom checklist is a self-report measure that was only administered to adolescents). If a caregiver, caseworker, or

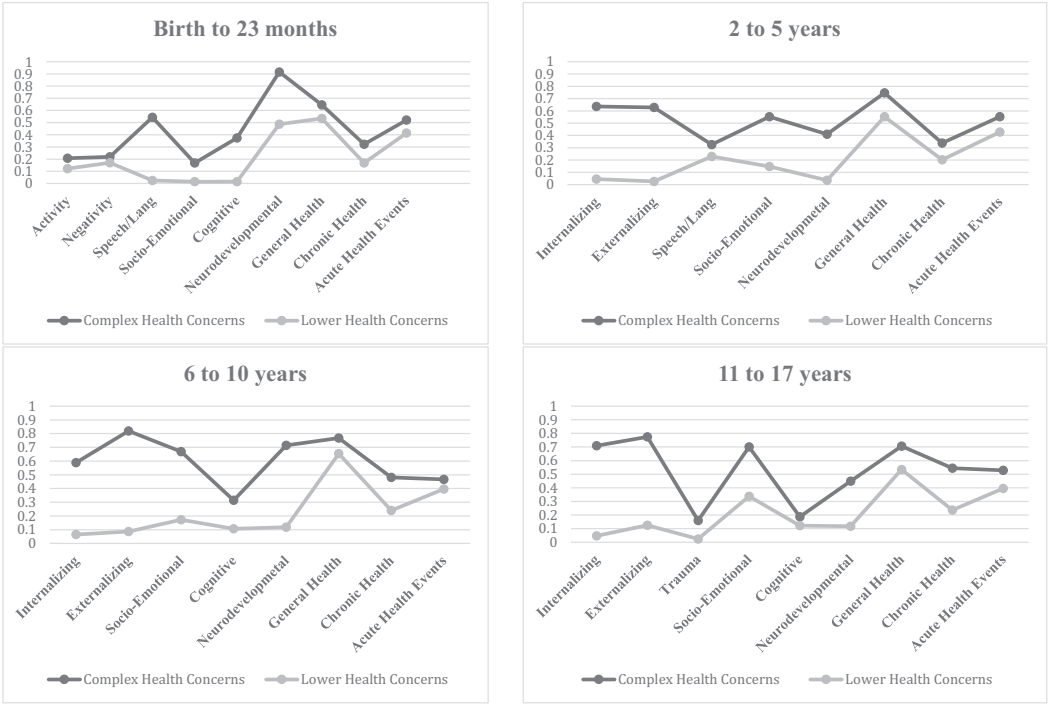

FIGURE 1 Proportion of child welfare–involved children in complex health concerns group (dark line) and lower health concerns group (light line) with behavioral, developmental, and physical health concerns by developmental stage. Adapted from Rienks et al[4]

child affirmed the presence of a particular health condition, or if a child's score on a behavioral or mental health tool exceeded clinical cutoff, the child was given a score of "1" for that indicator, demonstrating the presence of a concern. Most indicators were calculated based on two or more measures, most of which had at least two reporters. The established health concerns classes are further illustrated in Figure 1 (see Rienks, Phillips, McCrae, Bender & Brown[4] for more information). The complex health concerns class is primarily distinguished from the lower health concerns class by indicators of behavioral and mental health (less so by developmental or physical health).

2.3.2 | Independent variables

The adverse experiences of children were captured in nine dichotomously scored (0 = *no*, 1 = *yes*) items. Stambaugh and colleagues[1] created these ACE indicators using NSCAW data from children, caregivers, and caseworkers that most closely align with the ACEs identified in Felitti et al's study.[2] Given that the NSCAW did not ask specific ACE questions, researchers created ACE variables from available standardized measures, such as the Conflict Tactics Scale-2, Composite International Diagnostic Interview-Short Form (CIDI) measure of depression, demographic information, or questions developed for the study (eg, incarceration status, failure to supervise or provide for the child). These ACEs included the following: (a) physical neglect (eg, failure to supervise); (b) physical abuse (eg, hitting); (c) sexual abuse (eg, forced sex); (d) emotional abuse (eg, threatening); (e) domestic violence (involving household adults); (f) caregiver substance abuse; (g) caregiver mental illness; (h) family separation (eg, divorce); and (i) incarcerated caregiver.[14] An additional ACE, emotional neglect, was present in Stambaugh and colleagues'[1] work, but was not included in our analyses due to excessive missing data. Because our prior research indicated that children vary by developmental stage in the extent to which they experience complex health concerns, we also included a categorical variable for four developmental groups: birth to 23 months, 2-5 years, 6-10 years, and 11-17 years.

2.4 | Statistical analysis

Frequencies and percentages were calculated to describe characteristics of the full sample as well as characteristics of the sample according to health concerns. Next, CART analyses[23] were conducted to examine the relationships between ACEs and complex health concerns. Unlike other analytic approaches that estimate the average effect of an independent variable on an outcome variable (eg, logistic regression), CART has the ability to segment samples into groups based on shared characteristics and identification of the most salient independent variables. In other words, CART is a nonparametric statistical method that generates a decision tree to indicate combinations or clusters of attributes among a sample and their association with a particular outcome of interest.[23] CART begins with binary splits of the data into "parent nodes" that are then split into "child nodes" to determine which clusters of variables are most strongly associated with an outcome variable based on split criteria.[23] A decision tree is produced in which the process of splitting is applied recursively such that the data are split multiple times until no further splits improve the classification error rate (ie, the cost associated with misclassifying cases to the outcome), sensitivity (ie, true positive, ability to correctly classify those with a particular outcome), and specificity (ie, true negative, ability to correctly classify those without a particular outcome) of the model. Moreover, CART produces a tree that can be easily interpreted and visually useful for the development of screening or assessment tools.

To conduct our CART analyses, we first ran a classification tree model in SAS using PROC HSPLIT with the GROW = entropy and PRUNE=c45 options. A 10-fold cross-validation was used to confirm the fit of the model and select an optimal tree by separating the dataset into 10 mutually exclusive subsets where each subset is used as a testing dataset and the other subsets are aggregated to form training subsets. This procedure identifies the best fitting tree by estimating the model parameters and the validity of the model across the 10 subsets. Results for the entire sample did not produce a model that would be useful to practitioners. This is likely due to imbalance in the data as noted above (only 21 percent of the overall sample have more complex health concerns). To address this situation, we constructed models using the entire NSCAW dataset and the CORElearn statistical software package in R, using both the Hellinger and the DKM methods to grow a tree model, which are recommended to address unbalanced data. The models in R were also pruned using the m-estimate,[24] and we employed 10-fold cross-validation, as in the SAS models. The Hellinger method again produced an elevated error rate of 77.9 percent, and the DKM method had an error rate of 76 percent for classifying the sample into the complex health concerns group when using the entire dataset, despite the fact that Hellinger and DKM are recommended for unbalanced data.[25] Therefore, we chose to undersample lower health concerns by taking three different random subsamples of this group to create three balanced samples in which an equal number of children had complex and lower health concerns. Then, we conducted three separate analyses in SAS, one with each subsample. In each analysis, we selected subtrees with the highest power. To handle missing data, the ASSIGNMISSING = similar option in SAS PROC HSPLIT was employed. The method assigns missing values to the most similar node where similarity is determined by use of a chi-square test.

3 | RESULTS

3.1 | Demographic characteristics

Table 1 includes demographic characteristics and distribution of ACEs for the full sample and subsamples by health concerns class for children. In the full sample, the majority of children identified as having lower health concerns (79.0 percent) as opposed to

TABLE 1 Demographic characteristics for full sample and subsamples by health concerns class for child welfare–involved children

	Full sample		Subsample 1	Subsample 2	Subsample 3
	Lower health concerns (n = 4636)	Complex health concerns (n = 1234)	Lower health concerns (n = 1238)	Lower health concerns (n = 1238)	Lower health concerns (n = 1238)
Characteristic	n (%)	n (%)	n (%)	n (%)	n (%)
Age					
0-23 mo	2337 (50.4)	271 (22.0)	621 (50.2)	621 (50.2)	621 (50.2)
2-5 y	958 (20.7)	199 (16.1)	257 (20.8)	257 (20.8)	257 (20.8)
6-10 y	725 (15.6)	327 (26.5)	194 (15.7)	194 (15.7)	194 (15.7)
11-17 y	616 (13.3)	437 (35.4)	166 (13.4)	166 (13.4)	166 (13.4)
Gender					
Female	2326 (50.2)	529 (42.9)	637 (51.5)	651 (52.6)	617 (49.8)
Male	2310 (49.8)	705 (57.1)	601 (48.6)	587 (47.4)	621 (50.2)
Race/ethnicity					
White	1590 (34.3)	465 (37.7)	409 (33.1)	413 (33.4)	439 (35.5)
Black	1271 (27.4)	300 (24.3)	339 (27.4)	339 (27.4)	339 (27.4)
Multirace	403 (8.7)	96 (7.8)	122 (9.9)	114 (9.2)	89 (7.2)
Hispanic	1279 (27.6)	348 (28.2)	341 (27.6)	341 (27.6)	341 (27.6)
Other	73 (1.6)	22 (1.8)	19 (1.5)	23 (1.9)	22 (1.8)
Placed out of home					
No	2887 (62.3)	747 (60.5)	777 (62.8)	784 (63.3)	771 (62.3)
Yes	1749 (37.7)	487 (39.5)	461 (37.2)	454 (36.7)	467 (37.7)
Adverse childhood experiences					
Physical neglect	2137 (46.1)	678 (54.9)			
Physical abuse	1045 (22.5)	476 (38.6)			
Sexual abuse	322 (6.9)	244 (19.8)			
Emotional abuse	2021 (43.6)	785 (63.6)			
Domestic violence	1985 (42.8)	524 (42.5)			
Caregiver substance abuse	2134 (46.0)	408 (33.1)			
Caregiver mental illness	1710 (36.9)	588 (47.6)			
Caregiver separation	2778 (59.9)	786 (63.7)			
Incarcerated caregiver	554 (11.9)	137 (11.1)			

Note: Complex health concerns group demographics remained the same for analyses when analyzed with each lower health concerns subsample.

complex health concerns (21.0 percent). Over half of the children in the complex health concerns group experienced emotional abuse (65.9 percent), family separation (63.7 percent), and physical neglect (58.2 percent). This group predominantly included children aged 11-17 years (35.4 percent), followed by children aged 6-10 years (26.5 percent), birth to 23 months (22.0 percent), and 2-5 years (16.1 percent). This group also included slightly more males (57.1 percent) than females (42.9 percent), with more than half remaining in caregivers' homes (60.5 percent), and identified racially and ethnically as white (37.7 percent), Hispanic (28.2 percent), black (24.3 percent), multirace (7.8 percent), and other (1.8 percent). As a result of stratification, each of the subsamples of children from the lower health concerns groups was similarly matched to that in the complex health concerns group with regard to gender, race and ethnicity, and out-of-home placement.

3.2 | CART Results

Using the entire NSCAW sample and the GROW=entropy and PRUNE=c45 options, the analysis produced a model with a cross-validated classification error rate for complex health concerns of 79 percent, a sensitivity of 21 percent, and a specificity of 95 percent. This model relied on the strong association of younger age and lower health concerns, and it did an excellent job classifying lower

TABLE 2 Proportion of child welfare–involved children classified into lower and complex health concerns groups

	Cross-validation matrix				
	Predicted				
Actual	Less severe health needs	More severe health needs	Error rate	Sensitivity	Specificity
Sample 1					
Lower health concerns	837	401	0.32	0.60	0.68
Complex health concerns	488	746	0.40		
Sample 2					
Lower health concerns	830	408	0.33	0.62	0.67
Complex health concerns	470	764	0.38		
Sample 3					
Lower health concerns	839	399	0.32	0.63	0.68
Complex health concerns	459	775	0.37		

Note: Sensitivity = true positives (ability to correctly identify those with complex health concerns); specificity = true negatives (ability to correctly identify those without complex health concerns).

health concerns. Only 5 percent of children with lower health concerns were incorrectly classified as having complex health concerns. However, only 21 percent of children with complex health concerns were correctly classified as such.

Consequently, we reran the classification tree model comparing the complex health concerns sample to each of the three lower health concerns subsamples. As shown in Table 2, the model from the first subsample had an error rate of 40 percent for classifying children with complex health concerns, half that of the model using the full dataset. This first model had a sensitivity of 60 percent (ie, 60 percent of children with complex health concerns were classified correctly) and a specificity of 68 percent (ie, 32 percent of children with lower health concerns could be incorrectly classified as having complex health concerns). The model using the second subsample had an error rate of 38 percent for classifying children with complex health concerns. This model had a sensitivity of 62 percent (ie, 62 percent of children with complex health concerns were classified correctly) and a specificity of 67 percent (ie, 33 percent of children with lower health concerns could be incorrectly classified as having complex health concerns). Finally, the model using the third subsample had an error rate of 37 percent for classifying children with complex health concerns. This final model had a sensitivity of 63 percent and a specificity of 68 percent. All metrics for error, sensitivity, and specificity are calculated based on the 10-fold cross-validation.

The best fitted tree is illustrated in Figure 2, which shows the important independent variables identified in each of the three CART analyses and the percent of children classified into the complex health concerns group. The first characteristic separating children by health concerns is age range. Specifically, in all three subsamples, 44 percent of children aged 2-5 years and 68 percent of children aged 6-17 years were classified into the complex health concerns group. Because children aged birth to 23 months had overwhelmingly lower health concerns, the CART model did not add any ability to classify children within this developmental stage.

Among children aged 6-17 years, those who experienced physical abuse were more likely to be classified into the complex health concerns group, ranging from 75 to 77 percent for each subsample. Among the subgroup of children aged 6-17 who experienced physical abuse, those who were exposed to caregiver mental illness were 82-84 percent more likely to be classified into the complex health concerns group. Therefore, for children aged 6-17 years, physical abuse and caregiver mental illness are identified as the ACEs that cluster together to characterize children into the complex health concerns group.

Among children aged 2-5 years, those who were exposed to caregiver mental illness were 56-57 percent more likely to be classified into the complex health concerns group, thereby suggesting that caregiver mental illness may be the most salient ACE. However, among the subgroup of children aged 2-5 who experienced caregiver mental illness, the tree further split into a subsequent node for each subsample, but differed with regard to the ACE risk factor. Specifically, in the first subsample, those who were exposed to caregiver mental illness and emotional abuse were 51 percent more likely to be classified into the complex health concerns group. In the second subsample, children were characterized by exposure to both caregiver mental illness and substance use and were 46 percent more likely to be classified into the complex health concerns group. Finally, children in the third subsample were 61 percent more likely to be classified into the complex health concerns group if they were exposed to both

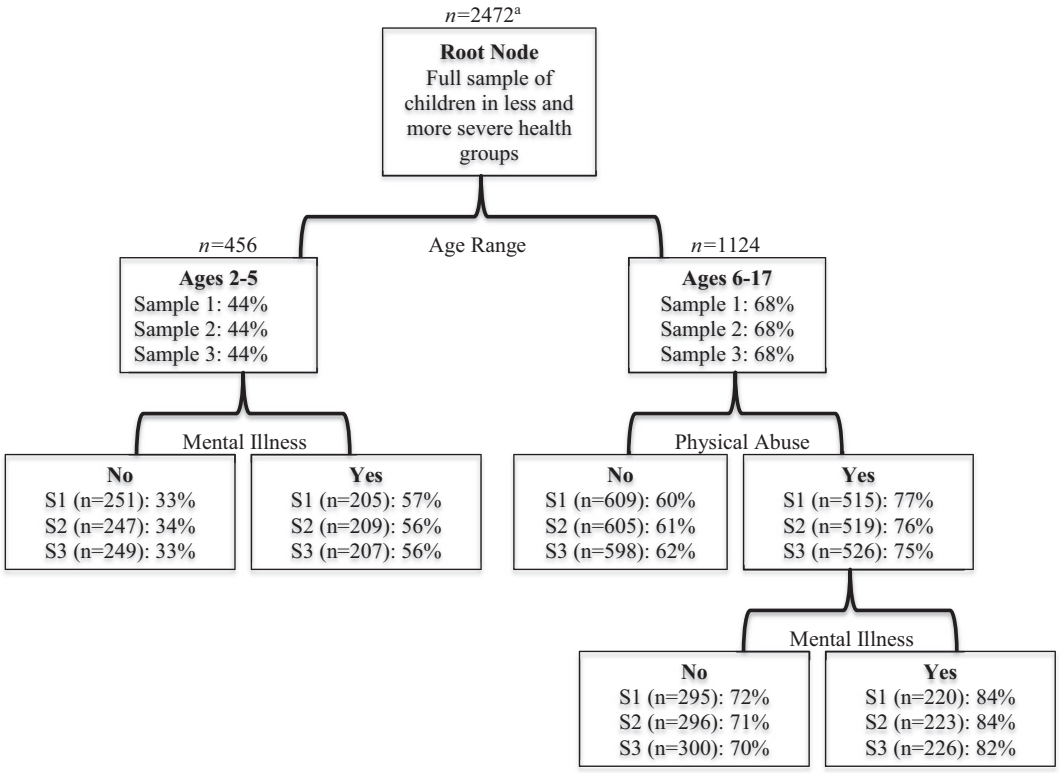

FIGURE 2 Pruned classification tree using adverse childhood experiences to categorize child welfare–involved children according to complex health concerns

Note. For each subsample (S), the percent classified into the more severe health group is reported. [a]Total sample size including children aged birth to 23 mo; however, this age group is not displayed in the figure as analyses were unable to classify children within this developmental stage.

caregiver mental illness and domestic violence. Given that the final nodes of each subsample varied by ACE risk factors and only slightly more than half of these children can be classified into the complex health concerns group, we suggest that these findings be further explored. We present the most parsimonious tree across subsamples in Figure 2.

4 | DISCUSSION

This study utilized CART analysis to produce a decision tree that identifies salient ACEs and their interactions in relation to complex health concerns among child welfare–involved children. The findings offer greatest clarity for children between the ages of 6 and 17, where experiences of physical abuse alone, or experiences of physical abuse combined with having a caregiver with mental illness, are key factors associated with children having complex health concerns. In the sample used for this study, only slightly more than half of children aged 2-5 years were classified into the complex health concerns group; thus, we view findings for this age group as preliminary but offer somewhat consistent evidence that caregiver mental illness is a key adverse experience associated with diverse health concerns.

In the United States, physical abuse is the second most common form of childhood maltreatment, after neglect, with approximately 17 percent of cases of physical abuse substantiated in 2015.[26] Studies have investigated the effects of physical abuse in early childhood, associating physical abuse with mental health problems such as depression and anxiety, and with medical diagnoses.[27] In addition, physical abuse has been linked to developmental concerns such as deficits in emotional processing,[28] social isolation, and self-regulation.[29] Our findings add to this work, indicating physical abuse is associated with a combination of health needs (physical, mental, and developmental) in child welfare–involved children between the ages of 6 and 17 years, and suggesting those who experience such abuse are likely to have complex health care needs. Furthermore, physical abuse appears to have a particularly detrimental effect on children's complex health when combined with other adversity—specifically, caregiver mental illness.

Caregiver mental illness is one form of early adversity that may commonly co-occur with physical abuse. Caregiver mental illness has not been highlighted as a relatively influential ACE compared to other ACEs in previous research, yet the unfavorable effects of caregiver mental illness are well documented in the literature. Children of caregivers with mental illness, particularly those in low-income settings, are more likely to experience social impairment[30] and lower attainment in language, literacy, mathematical, and emotional development[31] as well as physical concerns, such as impaired growth and nutritional status.[32,33] Experiences of mental illness may prevent caregivers from adequately caring for their

children, increasing risk of maltreatment, which may heighten negative developmental and physical outcomes.[34] Furthermore, it is unclear whether elevated mental health challenges are antecedents or consequences of being involved in the child welfare system.[34] Still, the diverse negative child outcomes associated with caregivers' mental illness suggest not only a nature, but also a nurture effect—one potentially malleable with mental health and parenting intervention.

In sum, results of this study suggest that, compared to other ACEs, physical abuse and caregiver mental illness are relatively more likely to be linked to complex health concerns among child welfare–involved children, particularly when experienced in tandem. In fact, these two ACEs are likely to co-occur, with previous research indicating that negative parental affect (ie, depression, anxiety, and hostility) is associated with minor physical parent-to-child aggression.[35] Thus, children whose families are characterized as physically abusive with co-occurrence of caregiver mental illness may represent a high-risk subgroup that warrants more thorough and immediate evaluation followed by referral to relevant physical, mental, and/or developmental services.

4.1 | Limitations

The findings presented here are not without limitations and suggest need for additional inquiry. As this was an analysis of secondary data, our investigation of ACEs and their relationships to complex health concerns are limited within the parameters of the larger NSCAW study. The ACE measure used was intended to reflect early adversities identified in the seminal ACE study conducted by Felitti and colleagues,[2] yet proxy measures for specific adverse experiences were limited. Perhaps most notable was neglect, one of the most common and detrimental forms of maltreatment,[36] which was assessed only by caregiver or caseworker report of failure to supervise. This limited assessment of an important ACE may have reduced our ability to detect its relationship to child health. It is also possible that other adversities experienced in childhood but not assessed in this study may impact children's health outcomes. For example, Finkhelhor and colleagues[37] found that other factors, such as peer relationships, poverty, and neighborhood violence contributed significantly to mental and physical health problems in a nationally representative sample of children. Moreover, the use of a cross-sectional design constrained our ability to draw casual conclusions, as it may be the case that children with complex health needs are more vulnerable to specific types of ACEs. Finally, our decision tree was limited due to the inability to accurately classify children aged 2-5 into the more complex health concerns group with each subsequent tree partition because ACE risk factors varied across subsamples. An unpruned model with very small node sizes may be overfit to the specific dataset used to develop the model and thus may not be as useful for predicting classifications with different data. However, a larger sample size would have allowed the use of more ACEs for classification while still preserving sample size at each node.

4.2 | Implications

Despite these limitations, our findings have important implications for research and practice. Given the exploratory scope of the study, there is a need for further research on ACE associations and their relative importance to different health outcomes among children involved with child welfare. Further research should employ longitudinal data that will allow for the identification of specific ACEs that characterize children with complex health concerns over time. In addition, future work that examines which ACEs are less likely to be associated with poor health outcomes among vulnerable children may also yield important information.[37]

Findings from this study have the potential to inform the development of screening approaches in health care and child welfare settings to help explain how specific adversities or combinations of adversities experienced in childhood increase risk for specific health trajectories.[15] In order to increase attention to adversities experienced among children, it may be necessary to first enhance professionals' knowledge and change their attitudes regarding ACEs and their associated health consequences. Despite the fact that some health care professionals may lack awareness of the effects of ACEs, the shortage of available brief and applicable screening approaches may be more responsible for low rates of screening for early adversity and the resultant unmet health needs among child welfare–involved children. For example, Burns and colleagues[3] found that nearly half of children between the ages of 2 and 14 who were investigated for maltreatment had clinically significant emotional or behavioral problems, yet only one-fourth of these children received any specialty health services. Existing full assessment batteries used to examine health risk are often expensive and time-consuming, which may result in their inconsistent use in health care and child welfare practice. Brief screening approaches to identify health risk may be particularly useful across a variety of professional settings that serve vulnerable children.

Although ACEs identified by Felitti and colleagues[2] are commonly used to screen for individual and cumulative adversity among adults,[38,39] few tools exist that screen for ACEs among children.[37,40-43] There are also a limited number of models for how to integrate ACEs into health care for children. The Center for Youth Wellness in San Francisco is one example that screens all patients aged birth to 18 for ACEs, and provides counseling, referrals, and multidisciplinary integrated health care.[44] In addition, Safe Environment for Every Kid (SEEK)[45] uses multiple methods (such as medical chart review) to assess exposure to and risk for maltreatment during pediatric health care visits, but this method does not directly assess ACEs.

Among the child welfare and health care agencies that do screen for ACEs with children, barriers to screening still exist. For example, general trauma screening approaches are increasingly being used within the child welfare system to evaluate whether children have been exposed to potentially traumatic events and children's associated reactions to these traumas.[46] However, workers report barriers to administering trauma screenings, including lack of training on how

to implement tools and concerns regarding how to use the information from screening to make referrals for services.[46] Findings from the current study could be helpful in developing and testing shorter screening tools that are more easily implemented among child welfare workers and other social service professionals. Highlighting those ACEs that, in certain combinations, are associated with greatest health risk could be valuable in saving workers time and providing clarity regarding which children on their caseload may be at highest need for complex health services.

5 | CONCLUSION

Regarding complex health concerns, a decision tree with physical abuse and caregiver mental illness in addition to cumulative ACE scores may help practitioners to more effectively and efficiently screen for ACEs and address the needs of children exposed to early adversity. Despite error rates in the CART model of up to 40 percent (which would be too high for some applications), implementing a brief screen of children who may fall within the risk groups identified in this study could rapidly inform the selection of initial health-promoting interventions used among this population. For example, children aged 2-5 years who are classified into the group with caregiver mental illness may benefit from interventions that aim to improve caregiver mental health and/or help caregivers navigate preventative health services for their children, whereas children aged 6-17 years who are classified into groups with exposure to physical abuse and caregiver mental illness may benefit from interventions that aim to mitigate the risks associated with physical abuse in addition to caregiver mental illness while connecting children with medical homes to meet potential complex health needs. Although our findings are preliminary and would be strengthened from further validation with large, diverse samples, they provide results to inform future research and the development and testing of new screening approaches among children exposed to early adversity.

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CONFLICT OF INTEREST

None.

ORCID

Samantha M. Brown https://orcid.org/0000-0002-7704-8120

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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